Testimony of Richard M. Duffy
On behalf of
The Uniformed Professional Fire Fighters Association of Connecticut
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Good afternoon, I am Richard M. Duffy, Assistant to the General President for Occupational Health, Safety and Medicine at the International Association of Fire Fighters. This afternoon I will discuss the important topic of chemical-induced cancers that our Public Safety and Emergency Response personnel, fire fighters in particular, may be subjected to while performing their duties. On behalf of fire fighters throughout the State of Connecticut, we are here today to discuss evidence that links higher rates of certain diseases with occupations that involve fire fighting emergency response activities, particularly when that response occurs in a dangerous environment containing unknown hazards. The known and potential risks to which these individuals are exposed, on our collective behalf, certainly warrants the passage of legislation that addresses the job-related health consequences suffered by our emergency responders.

Before going ahead, I believe it is important for you to understand what our organization is and whom we represent at these hearings. The IAFF is an international union affiliated with the AFL-CIO and the Canadian Labour Congress. At the present time, we represent over 280,000 paid professional fire service employees in the United States and Canada. The membership of the IAFF is employed by various parties that include the federal government, states, counties, municipalities, fire districts, airports, industrial manufacturers, and so on.

The IAFF has been actively involved in the health and safety problems of fire fighters for more than fifty years. Each year we conduct an annual *Death and Injury Survey* with the cooperation and participation of various fire department administrators. This survey has shown that fire fighting is among the most hazardous occupations in the United States. During the ten year period, 1990-1999, the annual *Death and Injury Survey* has found that professional fire fighters experienced 342 line-of-duty deaths, over 500 occupational disease deaths, 349,509 injuries and 6,577 forced retirements due to occupationally induced diseases or injuries. Fire fighter line-of-duty fatalities have ranked fire fighting among other publicized hazardous occupations in the private sector, including mining and construction.

Of the injuries reported, approximately 80% occur while at the emergency scene. Sprains and strains are the leading cause of on-duty injury followed by lacerations and contusions, burns, inhalation of hazardous materials, and eye injuries. The data showed that more than 38% of all fire fighters are expected to suffer an injury at least once during the course of the year. Occupationally related diseases, including heart disease and cancer, constitute more than 90% of all reported fire fighter deaths when their occurrences are combined.

This afternoon, I will specifically address the known associations between fire fighting and chemical-induced cancers.

I will address:

- The phases of fire fighting;
- Fire fighter exposure studies;
- Prevalent fire fighter cancers and associations with such exposures; and
- Conclusions regarding the importance and need for this legislation.

Phases of Fire Fighting

- Fire fighting involves not just fire suppression but:
    - Knockdown, which refers to active fire fighting, where respirators and other personal protective equipment (PPE) are not 100% effective in preventing

exposure, especially with substances that can enter the body through respirations;

- Overhaul, which involves the destruction of existing structures after the fire has been put out. This phase is a search for fire extension and an attempt to determine the cause of the fire. It is important to note that respirators are commonly not used during this phase, leaving fire fighters exposed to inhalational carcinogens in soot as well as other carcinogens like asbestos;

- Clean-up after a fire, in which carcinogens in soot/residue on PPE may be absorbed, particularly through hydrated skin;

- Firehouse exposures, where fire fighters spend long hours and are repeatedly exposed to diesel exhaust, an established carcinogen. Diesel exhaust from fire trucks, particularly if engines are run in closed houses without direct venting to outside air, may lead to high levels of diesel exhaust emission particulate.

Fire Fighter Exposure Studies:

Practically every emergency situation encountered by a fire fighter has the potential for exposure to carcinogenic agents. The list of potential carcinogenic agents to which fire fighters can be exposed is almost as long as the list of all known or suspected carcinogens, or over 700 agents. Despite the ominous risk of exposures, fire fighters knowingly enter potentially toxic atmospheres without adequate protection or knowledge of the environment. Fire fighters in Connecticut are exposed to toxic and carcinogenic substances at fire scenes as well as other emergencies such as chemical spills. The long term health effects of exposures from routine fires combined with unique chemical spills may not be apparent to fire fighters until long after the memory of that incident is gone.

Fire fighters, unlike most workers in this country, have little information about the many materials to which they are potentially exposed or the hazards of such exposures. Nevertheless, fire fighters continue to respond to the scene and work immediately to save lives and reduce property damage without regard to the potential hazards that may exist. A fire emergency has no controls or occupational safety and health standards to reduce the effect of toxic chemicals and carcinogens. It is an uncontrolled environment that is managed by fire fighters using heavy, bulky, and often times, inadequate personal protective equipment. The experience is not only physically demanding, but also involves exposures that are known to cause cancer.

Firefighters are routinely exposed to complex and dynamic mixtures of chemical substances that are contained in fire smoke and building debris. Despite the large numbers of people employed in this occupation, the nature of these exposures is not well defined. Nevertheless, I will outline numerous studies to date that demonstrate that firefighters are routinely exposed to carcinogens including the following:

Benzene

Benzene is firmly established as a human carcinogen. Numerous studies have shown that benzene is a common airborne contaminant in fire smoke and occurs in concentrations that are considered deleterious in the context of chronic exposures.

In the Harvard study, Treitman, Burgess, and Gold studied ambient environmental levels of a number of air contaminants, including benzene, at more than 200 structural fires. Benzene was detected in 181 of 197 (92%) samples taken at fire scenes by air sampling units placed on the chests of fire fighters. Half of the samples showed benzene over 1 part per million (ppm), the current Occupational Safety and Health Administration (OSHA) permissible exposure level. Approximately 5% of the samples were above 10 ppm benzene.

In Dallas, Lowry and colleagues studied fire fighters' exposure to benzene at nearly 100 structural fires. They found benzene at the majority of the fires and also detected the presence of at least 70 organic chemical species regardless of whether synthetic materials were a major part of the materials burned.

In Buffalo, Brandt-Rauf and colleagues used personal portable sampling devices to measure exposures of 51 fire fighters at 14 fires. The tubes of the sampling devices were attached to the fire fighters' turnout gear, thereby representing ambient air outside the mask. Benzene was second only to carbon monoxide as the most common chemical substance detected at the fires. It was detected in

18 of 26 samples from twelve of 14 fires. When detectable, the concentration of benzene ranged from 8.3 to 250 ppm. In only one sample where benzene was detected was its concentration below 10 ppm. Even when the smoke's intensity was rated as low, benzene was usually present in concentrations ranging from 22 to 54 ppm. The authors noted that respiratory protection was only partially used or not used at all at the fires judged to be of low smoke intensity.

Jankovic and colleagues at the National Institute for Occupational Safety and Health (NIOSH - the research institute for OSHA) studied benzene and other exposures at 22 fires, including 6 training fires, 15 residential fires, and 1 automobile fire. Samples were collected via probes placed inside and outside the masks of working fire fighters. In addition, industrial hygienists used a variety of sampling devices at the fire scene. Samples were taken separately during the two phases of a fire: knockdown and overhaul. Half of the samples taken during the knockdown phase of the fire showed benzene in concentrations of 1-22 ppm. Of the 29 organic substances analyzed, benzene was the most common compound detected and was the only substance present in all eight samples. To measure the efficacy of respiratory protection, samples for benzene were taken inside and outside the mask. Surprisingly, the levels of benzene inside the mask were as high as those taken outside the mask and ranged from nondetectable to 21 ppm. The authors attributed this equivalence in benzene concentrations inside and outside the mask to partial nonuse of the mask at the fire, especially after the initial phase of fire knockdown. They further suggested that the presence of benzene may begin only during the latter part of knockdown. During the overhaul phase of the fire, when respiratory protection is frequently removed, benzene was also found.

Asbestos

Asbestos, which has been used widely in buildings for its insulation properties, is universally recognized as a human carcinogen and is responsible for an excess risk of a variety of cancers in numerous occupations. Since the building destruction caused by fires and the building demolition actively performed by fire fighters during overhaul are likely to dislodge respirable asbestos fibers, the likelihood that fire fighters have exposure to asbestos is high.

In New York City, Markowitz and colleagues studied 212 fire fighters who had begun employment in the New York City Fire Department at least 25 years previously. Twenty of the 152 (13%) fire fighters, without any documented exposure to asbestos, had pleural thickening and/or parenchymal opacities on chest x-ray that were consistent with prior asbestos exposure.

The finding of excess risk of lung and pleural fibrosis due to asbestos among fire fighters indicated that significant asbestos exposure has occurred in this group. Since significant asbestos exposure confers excess risk for selected cancers, it is reasonable to expect that fire fighters have an increased risk of various cancers as a result of their exposure to asbestos.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a class of organic substances that have been implicated as the carcinogens in coal tar pitches, coal tar, and selected mineral oils. They have been associated with excess risk of a variety of cancers, including cancer of the skin, lung, kidney, bladder, colon, pancreas, stomach, pharynx, brain, and leukemia.

Given the combustion of diverse materials at fires, it is likely that fire fighters would be exposed to significant levels of PAHs. A study by Jankovic et al. evaluated the presence of PAHs at the scene of fires. All 14 PAHs measured were present during the knockdown phase of the fire.

Formaldehyde

Formaldehyde is considered a probable carcinogen. It has been measured at the fire scene by Lowry et al., Brandt-Rauf and colleagues, and Jankovic et al. Lowry et al. reported combined formaldehyde and acetaldehyde levels, with a mean of 5 ppm and a range of 1 to 15 ppm. Brandt-Rauf and colleagues found aldehydes, including formaldehyde, at 4 of 14 fires at concentrations of 0.1 to 8.3 ppm. Jankovic et al. detected formaldehyde at levels up to 8 ppm during knockdown and only 0.4 ppm during overhaul. They also reported that airborne concentrations of formaldehyde inside the mask ranged from nondetectable to 0.3 ppm. The current OSHA permissible exposure limit is 0.75 ppm for an 8-

hour-time-weighted average and 2 ppm for a 15-minute short-term exposure.

Diesel Exhaust

Considerable experimental and epidemiologic evidence gathered over the past 15 years suggests that constituents of diesel exhaust emissions are carcinogenic. Fire fighters have significant potential for exposure to diesel exhaust because fire trucks with diesel engines are routinely started inside of and backed into firehouses. Fire fighters spend much of the work shift inside the firehouse and obviously do not wear respiratory protection at the firehouse. Froines and colleagues studied the concentration of diesel exhaust particulates in the air inside firehouses in New York, Boston, and Los Angeles and detected significant exposure to diesel exhaust particulates that may be associated with a significant carcinogenic risk.

Other Agents

Acrolein is present in most fires as a combustion product of wood, cotton, carpeting and upholstery. Although its carcinogenicity is not well studied, one of its metabolites is a known carcinogen. Acrylonitrile is used in textiles and rubber for clothing, building materials, and household products. It is converted in the body to cyanide and causes cancer in animals and probably humans, especially cancers of the lung, prostate, stomach, colon, brain, blood, and lymphatic system. Vinyl chloride is used in the manufacture of plastics and present in building materials and consumer goods. It is known to cause cancer in humans, especially cancer of the liver, brain, lung, blood, lymphatic system, gastrointestinal system, and malignant melanoma.

Carbon monoxide and soot are found in all fires. Carbon monoxide is a natural product of combustion and, when inhaled, it blocks the body from being able to carry and use oxygen. It is believed to cause cancer in animals and possibly humans, especially liver and kidney cancer. Soot contains a variety of chemicals including PAHs and fire fighters often have direct skin contact with soot that penetrates their clothing. Soot is known to cause cancer in humans, especially cancer of the skin, scrotum, lung, liver, esophagus, and leukemia.

> Since the beginning of World War II, the production of synthetic chemicals has increased 350-fold in the United States. With the addition of thousands of synthetic chemicals annually, it becomes impossible to study the carcinogenic properties of each chemical. Furthermore, the latency period (the time from exposure to disease manifestation) for many cancers may be many years, and, therefore, it is difficult to identify the exposures responsible for adverse health effects (including cancer).

Fire fighters have a potential for exposure to multiple carcinogenic agents; many are known and many have likely not been identified. Despite the risk, fire fighters often enter potential toxic atmospheres without adequate protection or knowledge of the environment.

Fire Fighter Cancers:

When reviewing occupational studies of fire fighters, it is important to keep several points in mind. The first concept to remember is the healthy worker effect. Workers in general, and fire fighters in particular, tend to be healthier compared to the general population, which includes those who cannot work due to illness or disability. This idea is supported by the low all-cause mortality rates of fire fighters. In fact, a Paris study found the mortality rate of fire fighters to be half of the general population and a study in Seattle found a 25% lower mortality rate for fire fighters. A report by Samet pooled estimates from available studies in the literature and found an overall 10% lower mortality rate for fire fighters. These findings support the proposition that fire fighters are healthier than the general population. Therefore, when a study finds a mild to moderate increase in cancer or a lack of increase in cancer in firefighters compared to the general population it is very likely an underestimate. When a study finds firefighters to have *any* increase in cancer rates relative to the general population it is unsettling. When significantly higher than expected rates of cancer mortality are found in fire fighters compared to the general population it is very concerning. Comparisons with another group of "healthy" workers, such as police officers, rather than with the general population are therefore more likely to provide accurate estimates of occupational risks.

Second, the shortcomings of epidemiological studies are more likely to dilute or mask associations between occupational exposures of fire fighting and cancer than to create falsely positive associations. Fire fighters who are diagnosed with cancer after retirement from the fire service may not be included in these studies. In addition, death certificate information is often incomplete and may not reflect all cases of cancer, especially if cancer was not the primary cause of death. These oversights would further contribute to the underestimation of cancer rates and cancer deaths in fire fighters. For any given study, the lack of an association between fire fighting and a type of cancer is simply uninformative. It does not mean the relationship doesn't exist.

Third, in order for scientific studies to report "statistically significant" conclusions, the number of people studied must be large, especially when studying relatively rare diseases like certain cancers. Even if fire fighters from several regions are studied together, there may not be enough cancer cases to report "statistical significance" even though a relationship between exposure and disease may be present. When results *are* found to be statistically significant, it means we can be confident that the differences between 2 groups (in this case, fire fighters and the general population) is real and did not occur by chance.

Some studies investigate dose-response relationships to examine if the risk of disease increases as the dose of exposure increases. If a dose-response relationship is present, it is strong evidence for a causal relationship. However, the absence of a dose-response relationship does not rule out a causal relationship. In some cases in which a threshold may exist, no disease may develop up to a certain level of exposure, but above this level, disease may develop.

Finally, length of follow-up is important when studying cancer since many cancers develop decades after the exposure. Some studies that do not find an association simply may not have been long enough or did not include fire fighters who develop cancer after retirement.

Nevertheless, a number of studies have identified and established increased risk of cancer in fire fighters and identified associations with carcinogenic occupational exposures. The majority of studies that examined these cancers found *markedly* elevated risks for fire fighters, and there were usually no alternative viable hypotheses that could readily explain their increased prevalence. Epidemiological studies in the medical literature show that employment as a fire fighter increases the risk of developing and dying from the following specific cancers.

<u>Brain Cancer</u>

Chemical exposures that are suspected causes of brain tumors include vinyl chloride, benzene, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), N-nitroso compounds, triazenes and hydrazines.

Epidemiologic studies consistently have found that brain cancer is strongly associated with fire fighting. Several studies have found a 2-3 times excess risk of death for fire fighters compared to the general population. Statistically significant elevated risk of brain cancer death in fire fighters range from double the risk in a study of almost 6000 fire fighters from Toronto to 3.8 times the risk in 205 fire fighters from Hawaii.

Notably, a study by Demers and co-workers compared 4546 fire fighters with police officers. The all-cause mortality for both fire fighters and police was lower than expected to a statistically significant degree, indicating a healthy worker effect for both groups. Brain cancer rates, however, showed statistically significant increases among fire fighters compared to US males with 2.07 times the risk. An elevated rate also appeared when firefighters were compared to police with 1.63 times the risk. The increase among fire fighters compared to police is particularly important because police also had a higher rate of brain cancer than expected compared to US white men.

A study by Tornling and colleagues found dose response relationships between brain cancer incidence and increasing age, duration of employment, and years since hire, and between brain cancer mortality and increasing age, duration of employment, and estimated number of fires fought.

Cancers of the Digestive System

Several established occupational exposures increase the risk of cancer of the digestive system including asbestos, cutting and lubricating oils, dyes, solvents, and metallic compounds. In addition, fire fighters are exposed to soots and vinyl chloride, which are known human carcinogens that can cause cancer in the gastrointestinal system. Once cleared from the airways, inhaled particles and the carcinogens that adhere to them are transferred to the gastrointestinal tract by swallowing and exert their effect on the digestive epithelium. Some of the cancers that can result include:

- Colon and Rectal Cancer

Of particular relevance to fire fighters are the higher than expected rates of colon and rectal cancer observed in workers with exposure to asbestos. Excess colon and rectal cancer has been found consistently in many studies of fire fighters.

Ma and colleagues found more than double the risk of colon cancer for African American fire fighters, which was statistically significant. Vena and Fiedler, who studied 1867 fire fighters from Buffalo, New York, found a statistically significant increase of colon cancer risk for fire fighters that was 1.83 (or almost double) that of the general population. Further, they found that the risk increased to a statistically significant 4.71 (or almost 5 times) higher for fire fighters with the longest employment, suggesting a dose-response trend. Demers also found that colon cancer risk increased with length of employment, supporting a dose-response relationship. In addition, Demers found that when compared to police, fire fighters had a 58% (or 1.58) excess risk of colon cancer. In a study of 7789 Philadelphia fire fighters, Baris and others found a statistically significant increase in the risk of colon cancer which increased with over 20 years of employment.

Many studies have shown an increased risk of rectal cancer, with at least three studies showing a greater than two-fold risk. Orris and colleagues reported a statistically significant increase in rectal cancer among more than 3000 Chicago fire fighters. An analysis by Burnett and colleagues of mortality data for fire fighters from 27 states found a statistically significant excess risk of rectal cancer in fire fighters, which was almost double (1.86) for those under age 65.

- Pancreatic Cancer

Several studies have found an increased risk of pancreatic cancer among fire fighters, ranging from slightly elevated to two times the risk. When studies reporting pancreatic cancer were combined by Samet, the pooled estimate revealed a statistically significant increase in risk of pancreatic cancer for fire fighters. A Massachusetts study by Sama and colleagues found that the incidence of pancreatic cancer among fire fighters was more than three times the incidence in police officers.

- Stomach Cancer

Most of the epidemiologic studies that addressed stomach cancer found a positive association with fire fighting. The results ranged from a small increase in risk to a two fold increase in risk. Tornling found that both stomach cancer incidence and mortality increased with duration of employment and number of fires fought. Stomach cancer incidence was statistically significantly elevated by almost three times (2.89) for those with more than 30 years employments and by over two and a half times (2.64) for those who fought more than 1000 fires.

- Esophageal Cancer

Some studies have found an increased risk of esophageal cancer among fire fighters. A study by Beaumont and colleagues of over 3000 San Francisco fire fighters found that mortality from esophageal cancer occurred at twice the expected rate among fire fighters; this result was statistically significant.

- Pharyngeal Cancer

Few studies have reported on pharyngeal cancer, but generally rates have been increased in fire fighters. A meta-analysis of 32 studies by LeMasters and colleagues reported a summary risk estimate of 1.23 (or a 23% increase) based on available studies of buccal (oral) cavity and pharyngeal cancer, which was almost statistically significant.

<u>Cancers of the Genitourinary System</u>

- Bladder Cancer

Occupational chemical exposures known to cause bladder cancer include several aromatic amines, solvents, benzidine, PAHs, coal tars and pitches, soot and oils. These substances are commonly encountered by fire fighters, particularly at fires in commercial establishments.

The majority of epidemiologic studies found that fire fighting was associated with increased risk of bladder cancer deaths. Sama and colleagues found a statistically significant 2.11 (or more than double) increase in risk for fire fighters compared with police. Demers also found an almost two fold (1.7) increase in bladder cancer risk for firefighters relative to police. When compared to the general population, in a study of over 1800 fire fighters from Buffalo, Vena and Fiedler reported an almost three fold (2.86) increase in risk, which was statistically significant. Guidotti's study of more than 3300 Canadian fire fighters found a greater than three fold (3.16) increase in risk of bladder cancer compared to the general population. Further, both of these studies (Vena & Fiedler and Guidotti) found the highest rates in fire fighters with the longest duration of employment or greatest exposure index. These dose-response findings were statistically significant.

- Kidney Cancer

Occupational exposures that have been implicated as risk factors for renal cell carcinoma include asbestos, PAHs, lead phosphate, dimethyl nitrosamine, coke oven emissions, and gasoline. This list clearly includes agents encountered in fire fighting.

Several studies have found an increased risk of kidney cancer in fire fighters. Guidotti's study of more than 3300 Canadian fire fighters reported a greater than four fold increase (4.14) in risk, which was statistically significant. This study also reported statistically significant highest risk of kidney cancer among those with the longest employment and those with the greatest exposure index. The study by Tornling also found a dose-response trend, supporting this finding. The large study by Baris of more than 7700 Philadelphia fire fighters found a statistically significant elevated kidney cancer risk that was 2.2 times (or more than twice) the rate of the general population for fire fighters employed over 20 years.

- Prostate Cancer

High rates of prostate cancer have been reported among workers in a variety of occupations including chemists, farmers, loggers, textile workers, painters, and rubber industry workers. Fire fighters, specifically, are exposed to acrylonitrile and formaldehyde, both of which are considered probable causes of prostate cancer in humans.

Studies on prostate cancer have consistently found an increased risk in fire fighters. While the majority of studies found a 30-50% increase in risk, at least two studies have found a greater than double risk for fire fighters. Giles and colleagues found 2.09 times the rate of prostate cancer in Australian fire fighters compared to the general population. Grimes and colleagues found a statistically significant increase that was 2.61 times higher in fire fighters in Honolulu as compared to the general population.

- Testicular Cancer

Fire fighters report that their groin area frequently becomes covered with "black soot." Soot is a human carcinogen that is known to cause cancer of the scrotum.

Only a few studies have specifically addressed testicular cancer in fire fighters. Aronson and colleagues found higher than expected mortality for men employed by the Toronto Fire Department during a 40 year period, with an overall 2.52 times increased risk for fire fighters. An incidence study by Stang and colleagues found fire fighters were four times more likely to get testicular cancer. A meta-analysis by LeMasters determined a statistically significant summary risk estimate of two times (2.02) increased risk for fire fighters based on available studies.

<u>Cancers of Blood and Lymphatic Systems</u>

Leukemia and lymphoma are associated with environmental and occupational exposure to asbestos, benzene and 1,3 butadiene. The prevalence of benzene as a solvent, as a component of gasoline, and as a combustion product that forms during the burning of plastics and synthetics, and of 1,3 butadiene, a monomer found in tires and synthetic rubber products, guarantees that fire fighters will be exposed to gases released by these materials as they burn. Chemical exposures that have been associated with multiple myeloma include benzene and petroleum products.

- Leukemia

The majority of epidemiologic studies have found that fire fighters are at increased risk of leukemia. For example, Feuer and Rosenman reported a statistically significant increased risk of 2.76 times for fire fighters compared to police officers in New Jersey and an almost twofold increase in mortality compared to the general population in New Jersey and in the United States (1.77 and 1.86). Similarly, Sama and colleagues found that fire fighters had 2.67 times (or almost three times) the risk of police officers when incident cases reported to the Massachusetts Cancer Registry were examined. A large 1994 study from NIOSH combining mortality data from 27 states reported an excess risk of 1.71 for fire fighters younger than 65. Some studies found that the highest risk occurred among those with the longest employment, suggesting a dose-response relationship.

- Lymphoma

Several studies of fire fighters have evaluated this group of malignant diseases. Without exception, marked increases in risk were found. The study from the Massachusetts Cancer Registry by Sama found a statistically significant risk of 3.27 times for fire fighters relative to police officers. Studies by Giles from Melbourne, Australia, and Aronson from Toronto, Canada, reported that fire fighters had twice the risk of non-Hodgkin's lymphoma of males in the general population.

- Multiple Myeloma

Several studies have shown an increased risk of multiple myeloma among fire fighters. The analysis of a cohort of Seattle fire fighters by Heyer and colleagues reported a 2.25 (or greater than two fold) increase in risk of death from multiple myeloma for fire fighters. This risk increased to a statistically significant 9.89 for men with 30 years or more of fire combat duty. Howe and Burch combined the results of all cancer mortality studies of fire fighters available as of 1989 (including four unpublished reports) and concluded that there was a consistent evidence of a causal association between multiple myeloma and fire fighting. The meta-analysis by LeMasters and colleagues combined results from available studies through 2003 and found a statistically significant increase of 1.69 (or almost 70%) for death from multiple myeloma among fire fighters. An incidence study by Demers and collegues reported a 1.90 (or almost two fold) increase in risk for fire fighters.

Some studies have analyzed lymphatic and hematopoietic cancers together as a group. A review by the Industrial Disease Standards Panel (IDSP) of Ontario found that a strong, statistically significant association between fire fighting and blood and lymph cancers was identified in six studies with increase in risk ranging from 2.05 to 9.89. Four analyses also identified a dose-response trend.

Skin Cancer/Melanoma

The most common risk factor for cancers of the skin is prolonged and intense exposure to sunlight. Occupational exposure to soot and tars, coke oven emissions, arsenic, and cutting oils have also been associated with increased risk. Substances containing carcinogenic agents such as PAHs and PCBs may be absorbed by the skin of exposed body areas, including the hands, arms, face and neck, and other sites when protective clothing is permeated. Contact with these substances can occur during fire knockdown and overhaul and during the cleaning of clothing or equipment.

Most epidemiologic studies have found an increased risk of skin cancer among fire fighters. Feuer and Rosenman found a statistically significant 2.7 (or almost three-fold) increase in skin cancer mortality for New Jersey fire fighters compared to the U.S. population. Risk among fire fighters clearly increased with duration of employment. Sama and colleagues found that fire fighters had a statistically significant 2.92 (or almost three times) increase in the risk of melanoma, compared to the state population, when incident cases reported to the Massachusetts Cancer Registry were examined. Baris and colleagues found a statistically significant 3.1 (or greater than three times) increased risk of skin cancer in a subgroup of fire fighters from Philadelphia.

In summary, there is ample data to support the notion that fire fighters are exposed to carcinogens in their work environment.

The respiratory protection and other personal protective equipment used by fire fighters are of uncertain efficacy. Additionally, the protective equipment is often not used in overhaul and it carries carcinogens back to the fire station.

Apart from known carcinogens, fire fighters are potentially exposed to thousands of new synthetic chemicals being introduced into houses and commercial structures annually. The addition of these new chemicals adds to the uncertainty of risk that fire fighters face.

The data strongly suggest that fire fighters are at increased risk of developing and dying from cancer. Epidemiological studies demonstrate increased risk of several cancers that can be linked with carcinogenic exposures encountered by fire fighters in their work. Knowing the specific exposures, as well as the proven carcinogenic potential of these exposures, there emerges very strong evidence of biologic plausibility in occupational cancer causality. The following is a recap of just 5 of the many examples that demonstrate this connection.

- Brain cancer can be caused by chemical exposures to vinyl chloride, benzene, polycyclic aromatic hydrocarbons (PAHs), and other compounds that fire fighters are exposed to.

- Digestive system cancers can result from exposure to polychlorinated biphenyl compounds. Exposure measurements show that fire fighters are exposed to polychlorinated biphenyl compounds. Fire fighters are also exposed to asbestos, which is carcinogenic to the human gastrointestinal system.

- Genitourinary cancers can result from exposure to gasoline and polycyclic aromatic hydrocarbons. Exposure measurements show that fire fighters are exposed to gasoline and polycyclic aromatic hydrocarbons.

- Leukemia, lymphoma, and multiple myeloma (cancers of the blood and lymphatic system) can result from exposure to benzene and 1,3-butadiene. Exposure measurements show that fire fighters are exposed to high concentrations of benzene. In addition, vinyl chloride is a known human carcinogen for which there is sufficient evidence of an association with blood and lymphatic system cancers. Soot is also a known human carcinogen which has been linked with leukemia.

- Skin cancer can result from exposure to soot containing polycyclic aromatic hydrocarbons. Exposure measurements show that fire fighters are exposed to soot and polycyclic aromatic hydrocarbons.

Fire Fighters and Heart Disease

Similar to efforts addressing fire fighter's cancer experience, studies that link fire fighting with heart disease fall into three main groups--laboratory studies, field studies and epidemiological studies. The first, animal laboratory experiments have identified exposure to noise and certain chemicals (such as the common solvent carbon disulfide; carbon monoxide; arsenic; the common combustion by-products; polycyclic aromatic hydrocarbons; and elevated levels of the stress hormone, adrenalin) to contribute to the atherosclerotic process.

The second group, field studies, documents the exposure of fire fighters to these agents through industrial hygiene, biological, and physiological monitoring. Industrial hygiene data indicates that the fire environment contains a number of potentially dangerous toxins. Most frequent exposures, affecting the cardiovascular system, include carbon monoxide, poly aromatic hydrocarbons, cyanide, benzene, and hydrochloric acid. Arsenic as well as other toxic metals, organic solvents such as carbon disulfide, and many other toxins may also be present depending upon the products of combustion and conditions at the scene. Due to the highly unpredictable nature of the fire environment, it is almost impossible to predict with any certainty all of the exposures that could be encountered at any given fire. Blood testing of fire fighters has demonstrated elevated levels of carboxyhemoglobin, a biological marker for carbon monoxide exposure that exceed levels found in both the smoking and non-smoking population. Increased levels of urinary catecholamines (a metabolite of adrenalin) in fire fighters following fire operations, have demonstrated increased adrenalin levels. Electrocardiographic monitoring of fire fighters performing maximal exercise without the benefit of warm up time, a situation that mimics real conditions suggests diminished oxygen supply to the heart during the initial stages of activity under these circumstances.

The third group is epidemiologic studies of fire fighters and other occupational groups. This group of studies is performed to determine if exposures actually result in elevated rates of heart disease.

For example, the three epidemiologic studies of fire fighters in New Jersey, Connecticut, and Toronto, have demonstrated increased mortality rates from heart disease in comparison to the general population. However, there have also been a number of other epidemiologic studies that have not found an increased risk. This is due to a number of factors:

- Due to statistical constraints the number of individuals studied may not be sufficient to detect a difference.

- The studies rely on mortality, and measure only deaths from heart disease. Differences in survivorship between an occupational group and the general population resulting from disparities in the quality and accessibility of medical care or other factors, may result in misleading conclusions about disease prevalence;

- As mortality studies, the investigations rely upon death certificates that are frequently inaccurate and may erode the ability of the study to detect real differences.

- Due to the selection forces at the work place, occupational groups tend to be healthier than the general population with disease incidence significantly less than the general population. An increase in the prevalence of a medical condition arising from work place exposures may therefore-be missed with comparison to the general population. This "healthy worker effect" is accentuated with fire fighters that are extremely healthy, and has been termed the "super healthy worker effect". This problem may be controlled by using another, similar occupational group as a control. This has been accomplished in a number of studies of fire fighters using policemen as a comparison group. This may not be appropriate for the evaluation of heart disease, however, since a number of studies have also demonstrated an elevated rate of heart disease in policemen as well as fire fighters;

- When studying an occupational group, certain sub-populations may be at greater risk for a disease due to differences in exposures, administrative policies, or other reasons. The ability of a study to identify and establish the increased rates in these subgroups may be limited due to statistical and study design constraints.

Any of these factors could result in an otherwise well designed epidemiologic study failing to find an increase in the prevalence of an illness even if one existed (i.e. a “false negative” result).

Due to the difficulty in conducting reliable industrial hygiene monitoring in the dangerous and unpredictable fire environment, epidemiologic studies linking carbon monoxide exposure to heart disease in fire fighters have not been practical. However, studies with New York City tunnel workers and motor vehicle examiners have demonstrated chronic exposure to carbon monoxide to be associated with increased rates of heart disease. Recent epidemiologic studies have also demonstrated an increased rate of heart disease in shift workers. Although not conclusive, the epidemiologic data presented above does demonstrate an association with the exposures encountered during fire fighting and an increased risk of atherosclerotic heart disease.

Accordingly, it is the position of the International Association of Fire Fighters that cardiovascular disease is exacerbated by fire fighting duties and that fire fighting increases the incidence of cardiovascular disease in fire fighters. It has been well demonstrated that occupational heart disease is occupationally related to fire fighting.

Conclusions:

Although there are more questions to be answered, and more chemicals to be studied for adverse health effects, we believe that there is sufficient scientific and medical evidence to show that fire fighters suffer from cancer due to their exposures in performing tasks associated with fire fighting.

Currently, 37 states in the United States have legislation now in effect, that recognizes that if a fire fighter develops a heart or lung disease that it has occurred due to his profession. In addition, 23 states and New York City have adopted legislation, or revised compensation regulations, that presume that if a fire fighter develops cancer it is occupationally induced.

As our testimony has indicated, we strongly believe that sufficient evidence is available that shows fire fighters suffer from cancer, heart disease and infectious diseases due to their fire fighting exposures. Fire fighters face the possibility of death or injury every time they respond to an alarm where they provide emergency assistance to the citizens of Connecticut. While risk may be part of the profession, fire fighter deaths and injuries should not be accepted as part of the job. We believe it is time for you to enact legislation to clearly indicate that cancer, heart disease and infectious disease is occupationally related to fire fighting.

January 25, 2007

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Brother Keating,

I have reviewed the testimony provided by Dr. Henry Black opposing proposed presumptive heart and hypertension legislation for the state of Connecticut and besides the fact that the testimony was extremely dated (presented originally in 1983) the following are some points of interest.

In Dr. Black's testimony he stated that there is "No conclusive evidence that sustained hypertension has ever been shown to result from excessive job pressure or anxiety." In fact, JL Boone found that "Mental stress seems clearly and inextricably linked to the development and maintenance of high blood pressure. Blood pressure evaluated during ambulation, work, or mental stress instead of at rest or in the physician's office consistently improves the ability to predict the target-organ damage often associated with all forms of hypertension."[1] Also TG Pickering found that "Ambulatory monitoring has shown that most people have their highest pressures during working hours. Occupational stress can be evaluated as job strain, which is a combination of high demands at work with low decision latitude or control. Job strain has been related to coronary heart disease, and a number of studies have shown that it is also associated with higher ambulatory blood pressures, both cross-sectionally and prospectively, in men but not in women."[2]

Black also claims that "constant exposure to cigarette smoke is an extremely important determinant of the risk of heart disease, more so than the occasional intense exposure fire fighters get while on the job." There is no evidence to support this claim. However, carbon monoxide (CO) is formed by the incomplete combustion of carbon containing materials. Personal monitors worn by fire fighters have recorded very high concentrations of CO at fires.[3,4] Carbon monoxide decreases the oxygen carrying ability of the blood and poses acute and chronic health effects.

Carbon monoxide acts as a chemical asphyxiant and starves the heart of its normal oxygen supply by binding to the oxygen carrying molecule, hemoglobin. Carbon monoxide binds to hemoglobin 200 times more effectively than oxygen, so it takes only a small percentage of CO in the inspired air for hemoglobin molecules to become filled with CO. Once bound to hemoglobin, it is difficult to remove CO from the oxygen binding site. The net effect is that even low concentrations of CO in the air can have significant negative effects on the body's ability to transport oxygen.

At high CO exposure levels, the oxygen carrying capacity of blood becomes compromised and the death of myocardium (similar to a heart attack) can occur, even without any blockages in the coronary arteries. The physical demands of fire fighting increase the body's demand for oxygen and can worsen symptoms. High level of exposure can also result in loss of consciousness due to lack of oxygen sent to the brain. In persons with known ASCVD accompanied by angina, CO exposure has been shown to reduce exercise capacity and result in vulnerability to cardiac rhythm disturbances.[5] The reduced capability of the blood to carry oxygen following CO exposure functionally worsens existing heart artery blockages, resulting in decreased oxygen delivery to heart muscle without the blockages actually becoming larger.

Reduced exercise capacity and ischemic responses have also been shown in healthy young adults exposed to CO.[6] Long-term exposure to CO is suspected to cause the formation of atherosclerotic plaques. Since several studies demonstrated atherosclerosis developing at accelerated rates in animals chronically exposed to CO.[7] This hypothesis is reinforced by the observation that, in animals, chronic exposure to high concentrations of CO in cigarette smoke increases the risk of developing heart disease. The exact mechanism by which this occurs is unknown.

The evidence from epidemiologic studies is also suggestive that CO has the same effect in people. In northern Japan, chronic high-level exposures to CO have been reported to produce a seven-fold increase in ASCVD occurrence in tatami mat makers.[8] These workers heat their tightly sealed buildings with charcoal braziers. Likewise, New York City tunnel officers (chronically exposed to CO from auto exhaust) were found to have a 35% increase in risk of dying from ASCVD. This excess risk declined after tunnel ventilation improvements decreased tunnel CO levels.[9]

Since the only significant entryway for CO into the body is through the lungs, fire fighters can protect themselves from excessive exposure by proper use of personal protective equipment, such as the self-contained breathing apparatus.

Polycyclic aromatic hydrocarbons (PAHs) are a group of carbon compounds that are formed in most fires involving carbon containing materials, including wood, fuels and many man-made materials. Like carbon monoxide, studies of long term exposure to PAHs have shown an accelerated formation of atherosclerotic plaques in animals.[10] However, this association has never been clearly demonstrated in people. Unlike CO, PAHs are not asphyxiants. However, they are considered carcinogens in the lung and colon.

A number of other chemicals that can be present in combustion products can have adverse effects on the heart. Cyanide and hydrogen sulfide act as chemical asphyxiants, potentially resulting in myocardial ischemia. Arsenic and carbon disulfide exposure may contribute to atherosclerotic plaque formation. Lead, cadmium, and organic solvent exposure may contribute to the development of high blood pressure, thus indirectly affecting the heart.[11] The potential for exposure to these dangerous chemicals increases as the normal industrial mechanisms used to control exposure fail during fire and disaster situations.[12,13]

Dr. Black claims that "there is no proven medical evidence that any occupation has a significant effect on the chances of an individual developing either hypertension or coronary artery disease." TS Kristensen found that "the following classification of risk factors in the work environment seems to be well justified: Very probable causal relationships: Physical inactivity at work Nitroglycerine/nitroglycol Carbon disulphide Probable causal relationships: Monotonous high-paced work Shift work Noise Cobalt Arsenic Lead Possible causal relationships: Passive smoking Heat Dinitrotoluene Organophosphates Antimony Electromagnetic waves."[14]

Atherosclerotic heart disease is the major killer of adult men and women in North America. Analyses of the characteristics and habits of populations have delineated many factors which affect an individual's risk of developing ASCVD. Elevated blood cholesterol, smoking, high blood pressure, obesity, and sedentary lifestyle are the major "classic" risk factors that can be controlled by an individual's actions. These issues are important as studies in Los Angeles County safety personnel and Dallas fire fighters have revealed comparable rates of high blood cholesterol, tobacco abuse, hypertension, obesity, and poor physical conditioning in fire fighters when compared to the general population. In addition, fire fighters face important and unique occupational hazards, such as carbon monoxide exposure, extreme temperatures, noise, and psychological stress in the daily performance of their duties. By controlling both personal and professional risk factors, fire fighters can promote their long term cardiovascular health.

Fraternally,

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